FAULTY SENSOR DETECTION USING DATA CORRELATION OF MULTIVARIANT SENSOR READING IN SMART AGRICULTURE WITH IOT

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DEDICATION

In the name of Allah, the most Merciful, the most Compassionate, I dedicate this project to **Allah ALMIGHTY**, my source of knowledge and understanding.

I also dedicate this work to my beloved parents **Mr. DHAHIR** and **Mrs. SHUKRYA** for their encouragement and continued support. To my dear **Brothers** and **Sisters**. To my beloved wife **Mrs. ALYAA** for your patience and my dear **kids**. To my dear uncles **Mrs. TALIB and Mr. KADHIM** and my dear aunt **Mrs. RADHIA** Thank you all.

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ABSTRACT

The Internet of Things (IoT), the idea of getting real-world objects connected with each other, will change the ways we organize, obtain and consume information radically. Through sensor networks, agriculture can be connected to the IoT, which allows us to create connections among agronomists, farmers and crops regardless of their geographical differences. On the other hand, Sensor fault is critical in smart grids, where controllers rely on healthy measurements from different sensors to determine all kinds of operations. However, when sensor fault happens, missing data and/or bad data can flow into control and management systems, which may lead to potential malfunction or even system failures. This brings the need for Sensor Fault Detection and eliminate this potential fault. This thesis proposes to design a Faulty Sensor Detection Mechanism using the data correlation method of multivariate sensors. This method will be applied to the smart agriculture which uses multi-variate sensors such as moisture sensor, temperature sensor and water sensor in IoT. The data are collected and received by a microcontroller which also can be linked to the internet. According to the algorithm, which applied on the smart agriculture, in case, the system gives No FAULT when the correlation value between (temperature, moisture) and (temperature, water) are negative and positive for (Water, moisture). In other cases. The system has a fault in a sensor when the correlation values between sensors are changed. Also, when the sensor gives a constant reading for a long time the system has got a fault in this sensor. The system got No FAULT when was different in sensors reading and the correlation value between (temperature, moisture) is (-0.33), between (temperature, water) is (-0.16) and (moisture, water) is (0.36). In addition, this system will be connected to the internet through the ESP8266 module. In order to surveillance the system at anytime and anywhere, this system is connected with the cloud (Things board) by using an ESP8266 WiFi network connection. This would allow the system to be more efficient and more reliable in detecting and monitoring the system's parameters such as the state of sensors. The accuracy of the algorithm for data

correlation may be changing depending on the application that wants to detect the faulty sensor in the system and according to how many data that income to the microcontroller per minute and how many data should take to calculate the correlation coefficient. Therefore, for the smart agriculture which it's used in this project, the period is adjusted to give a good diagnose for the sensor as soon as possible.

ABSTRAK

Idea untuk menyambung objek dunia sebenar di antara saty sama lain iaitu dengan menggunakan teknologi yang dikenali sebagai Internet of Things (IoT) akan mengubah cara kita mengatur, mendapatkan dan menggunakan maklumat secara radikal. Melalui rangkaian sensor, pertanian boleh disambungkan ke IoT, yang membolehkan kita untuk mencipta sambungan antara agronomi, petani dan tanaman tanpa mengambil kira perbezaan geografi mereka. Di sisi lain, pengesan sensor yang rosak adalah kritikal dalam sistem grid pintar, di mana pengawal bergantung pada pengukuran yang baik daripada sensor yang berbeza untuk menentukan semua jenis operasi. Tambahan pula, apabila berlaku kerosakan sensor, akan berlakunya kehilangan data dan/atau data rosak di hantat ke dalam sistem kawalan dan pengurusan akan membawa kepada kerosakan potensi atau pun kegagalan sistem. Oleh itu, pengesan kerosakan sensor dan mengelakkan potensi kerosakan ini. Tesis ini bercadang untuk merekabentuk satu mekanisme pengesanan sensor yang rosak iaitu dengan menggunakan kaedah korelasi data daripada multi-variasi sensor. Kaedah ini akan digunakan untuk sektor pertanian pintar yang menggunakan multi-variasi sensor seperti sensor kelembapan, sensor suhu dan sensor air dalam IoT. Data yang dikumpul dan diterima oleh mikropengawal juga boleh disambungkan ke internet. Menurut algoritma yang digunakan dalam pertanian pintar, dalam kes sistem dimana memberi kolerasi NO_FAULT apabila nilai kolerasi (suhu, kelembapan) dan (suhu, air) adalah negatif dan positif bagi nilai kolerasi (air, kelembapan). Dalam kes-kes lain, sistem ini mengesan kerosakan sensor apabila nilai korelasi antara sensor berubah. Selain itu, sensor yang memberi bacaan yang sama untuk jangka masa panjang dikatakan sistem telah mengesan kerosakan pada sensor ini. Apabila tiada kesalahan (no fault) berlaku dalam sistem ini, nilai korelasinya adalah (suhu, kelembapan) (-0.33), (suhu, air) (-0.16) dan (kelembapan, air) (0.36). Di samping itu, sistem ini akan disambungkan ke internet melalui modul ESP8266. Hal ini, supaya pengawasan sistem pada bila-bila

masa dan di mana sahaja, sistem ini dihubungkan dengan cloud dengan menggunakan sambungan rangkaian ESP8266 WiFi. Ini akan membolehkan sistem supaya lebih efisien dan lebih dipercayai dalam mengesan dan memantau parameter-parameter sensor seperti keadaan sensor. Ketepatan algoritma bagi kolerasi data mungkin berubah bergantung kepada aplikasi yang ingin mengesan sensor rosak dalam sistem dan mengikut berapa banyak data yang diperolehi oleh mikropengawal dalam satu minit dan berapa banyak data diperlukan untuk mengira pekali korelasi. Oleh itu, untuk pertanian pintar yang dalam projek ini, tempoh dilaraskan untuk memberikan diagnosis yang baik untuk sensor secepat mungkin.

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LIST OF ALGORITHMS

LIST OF SYMBOLS AND ABBREVIATIONS

x_i	-	Reading of the temperature sensor
$\bar{x}$	-	Average of the temperature sensor reading
$\bar{y}$	-	Average of the moisture sensor reading
y_i	-	Reading of the moisture sensor
$\bar{z}$	-	Average of water sensor reading
z_i	-	Reading of the water sensor
C(T,M) < 0	-	Correlation between (T&M) is less than 0
C(T,M) > 0	-	Correlation between (T & M is larger than 0
C(T,W) < 0	-	Correlation between (T&W) is less than 0
C(T,W) > 0	-	Correlation between (T&W) is larger than 0
C(M,W) < 0	-	Correlation between (M&W) is less than 0
C(M,W) > 0	-	Correlation between (M&W) is larger than 0
C	-	Correlation
M	-	Moisture sensor
R	-	Correlation confections
T	-	Temperature sensor
W	-	Water sensor
DWT	-	Discrete Wavelet Transform
IOTs	-	internet of things
ITU	-	International Telecommunication Union
IDE	-	Integrated Development Environment
RFID	-	Radio-frequency identification
TTL	-	Transistor-Transistor Logic
UART	-	Universal Asynchronous Receiver/Transmitters

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CHAPTER 1

INTRODUCTION

1.1 Background of Study

Internet of things becomes a modern system in that all things around us are linked to the network. Though the term “IoT” has been now commonly applied, the general definition of IoTs is still in the establishment procedure [3][5]. The ITU describes IoT as “an universal infrastructure for the data society allowing developed solutions through inter-connecting virtual and physical objects based on evolving inter-operable data and communication methods” [21][6]. Based on Cluster of European Research Projects on the IoT, IoTs could be considered a dynamic worldwide network infrastructure with simply integrated active contributors [4].

The IoT could be approached as a mix of the Internet network, configured sensors and near field communications. Approaching this technology causes fresh business chances (e.g., automobiles with configured sensors, smart thermostats and jet which are prepared with modern sensors to monitor remotely) [11].

Small Smart network Sensors are used in various industries such as Smart Home, Exact Farming, Logistics and Industrial Automation. Equipped with smart sensors, this device has the capabilities of identity, identification, networking and processing. By giving each device a unique ID, it generates unprecedented data and creates new business chances [9].

IoT environments such as precision agriculture are becoming increasingly well-known and get increasing focus over the past decades. Applying smart sensors and intelligent actuators, these IoT solutions provide easy applications to cultivator. Though applications of IoT are lightweight tools exposed to strict surroundings and have restricted computational abilities that lead to recurrent faults [1].

Smart sensors suffer generally from several kinds of faults because of hardware faults, restricted life of battery, or faults of human [2] these faults in IoT surroundings are specifically critical and might cause terrible effects. So that, keeping the integrity of the information is a vital necessity in IoT applications [7].

1.2 Problem Statement

In recent years, modern agriculture has become increasingly popular and have received growing attention. However, this field become one of the most interesting areas for researchers and developers. Therefore many researches try to develop this application by connect the sensors of this agriculture with internet through IoT technology. Using these sensors would allow full monitoring and controlling of these agriculture from anywhere and anytime. Conversely, these sensors are of course, very sensitive cannot handle severe weather conditions such as high wind, heavy rain and high humidity. These bad condition cause many sensor damage after a period of time, based on this damage the sensor reading will be inaccurate. For example, at a hot day disrupts the moisture sensor and the reading of the sensor become high moisture in the soil. The system will turn off the water pump as per moisture sensor reading. This action can cause great damage to agricultural crops, which leads to the lack of production and the failure of the smart system. In addition, the weakness of this system may using large amounts of water in watering. Thus, the system does not provide the most important characteristics that must be provided in smart agriculture which is the provision of water. In order to solve this problem is to developing smart faulty system detection for smart agriculture based on used the reading three sensors temperature sensor, moisture sensor and water sensor) to detect fault in device by compared these reading using correlation algorithm.

1.3 Objectives of the Study

The purpose of this research is as listed below:

(i) To propose a Faulty Sensor Detection Mechanism using multivariate sensor based on the data correlation method in smart agriculture application.

(ii) To implement the proposed faulty detection mechanism into a developed prototype of smart agriculture system based on Arduino with IoT platform. The prototype collects information about soil temperature, soil moisture and water sensor.

(iii) To evaluate and determine performance in term of accuracy of the proposed faulty sensor detection mechanism.in a real environment of smart agriculture applications.

1.4 Scope of Project

To achieve the objectives, the scope of this research is as the following.

1. Do literature review on the previous existing faulty sensor detection mechanism in.
2. Build precision agriculture system which consists of three sensors (water sensor, moisture sensor and temperature sensor). Water sensor which response for measure percentage of water, moisture sensor which measure humidity of soil and temperature sensor which response for measure soil temperature. Therefore Arduino Uno which make action depended on the input.
3. This system able to recognize which sensor have got fault based on data which get from three sensors (water sensor, moisture sensor and temperature sensor) for certain time using data correlation algorithm.
4. Implementing IoTs cloud using ESP8266 Wi-Fi wireless communication system, and upload to cloud server to achieve remote monitoring and controlling via internet Thingsboard platform.

1.5 Importance of project

The importance of this project are as follows:

- The design is intended to give information of the current soil data status in the agricultural area. Besides, the system also be user friendly and can be accessed anywhere as long as user have internet connection.

- This fault sensor detection and location recognize system is capable of data show when fault is detected, which is very important for farmers and care of agricultural land.

1.6 Thesis organization

- **Introduction:** this chapter defines the objectives and scope of the project in addition to the structure of the research.
- **Literature review:** Written and complete description of previous work in the field of accredited researchers and researchers. It refers directly to the thesis and provides information on the theories, models, materials and techniques used in the research.
- **Methodology:** this significant chapter shows accurately the examples, tools, materials, processes and information collecting ways applied in the project.
- **Findings and analysis:** this chapter shows the data analysis methods and findings in text, graphs, figures, tables etc.
- **Discussion and conclusions:** approach the findings by comparing them with the last works demonstrated in the LR. Next research is also expained.

CHAPTER 2

LITERATURE REVIEW

2.1 Introduction

Internet of Things' (IoT) is far and wide castoff in relating devices and gathering statistics. This farming monitoring system serves as an efficient design. it also allows clients to notice precise alteration in fields. It is inexpensive; the design is more effective and useful for clients. It gives the information about sensitive the temperature, humidity, water of the soil in farming field [10].

Generally speaking, the sensor may be vulnerable to two common faults, such as malfunctions and data. First, there is a data center display containing faults such as external, peak, destructive, and noise. On the other hand, there is a session - oriented screen that includes faults, such as hardware, blank batteries, and shifts [11]. The fault diagnosis techniques are categorized according to the nature of the examines, correlation among readings of sensors and features [12] [13].

Furthermore, our system relates to fault detection of the sensors at precision agriculture applications more specifically, the present thesis relates to a sensor data correlation method and apparatus for correlating sensor faults over real-time in order to perform fault management and monitor the data true for devices in IoT.

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2.2 Internet of things (IoT)

2.2.1 Concept of IoT

The International Telecommunication Union describes IoT as “an universal infrastructure for the data society allowing developed solutions through inter-connecting virtual and physical objects based on evolving inter-operable data and communication methods” .According to Cluster of European Research Projects on the Internet of Things [9].

The world is moving from isolated systems to Internet-based matters everywhere that can communicate with one another and produce data that can be analyzed for valuable information. The highly intertwined global network, known as the Internet of Things, will enrich everyone's lives, increase business productivity, increase government efficiency and maintain the list [8].

However, this new Internet-based reality (IoT) presents new challenges, especially in terms of security and privacy. Internet devices communicate with each other with little human interaction, mutual authentication is a critical aspect of the model. In a vibrant and intelligent system, sensors are connected to transmit useful information and control instructions through distributed sensor networks [8].

In order to support these connections, industry and research come up with a low powers physical and transport network protocols such as Blue-tooth, IEEE 802.15.4, ZigBee and, more lately, low power Wi-Fi and 6LoWPAN.These developments help towards integrating smart things into a network of internet. [16].

Figure 2.1: Smart things having communication capabilities [16]

The future Internet will be an IPv6 network that connects traditional computers to multiple intelligent objects or networks, such as wireless sensor networks (WSNS). The Internet of Things (IoT) will be the foundation of many services and will depend on their availability and reliable operation in our daily lives. Therefore, among other things, the problem of secure communication on the Internet of things must be solved [8].

The use of IoT technology in agricultural areas has been the subject of much research and development. However, IoT in agriculture must be treated differently in different sectors, such as industry and logistics. Cloud-based wireless systems help maximize crop yields and cultivation tasks, and also provide real-time tracking of intelligent solutions that help farmers analyze and improve crop areas. For this purpose, built-in wireless devices and other automated electronic systems are used to measure moisture and detect faults, measure temperature and use energy efficiently. Remember to know all the big decisions [17].

2.2.2 Attributes of IoT

IoT is based on the strong technological advances and vision of a network that is being realized diligently. This means that short-range mobile transceivers are embedded in everyday objects, enabling new communication between people and things and between things themselves. We can understand the IoT's attributes of both parties: technology and applications [18].

The first features of SP: spam and non-specific billing systems are crucial for connecting everyday objects and devices to large databases and networks: objects can only be assembled and processed. RFID offers this feature. Second, the ability to detect the physical state of objects using touch tactics is useful for data collection. The intelligence capabilities attached to the same objects can be further extended to network capacities by transferring network capacities Figure 2.2. [19].

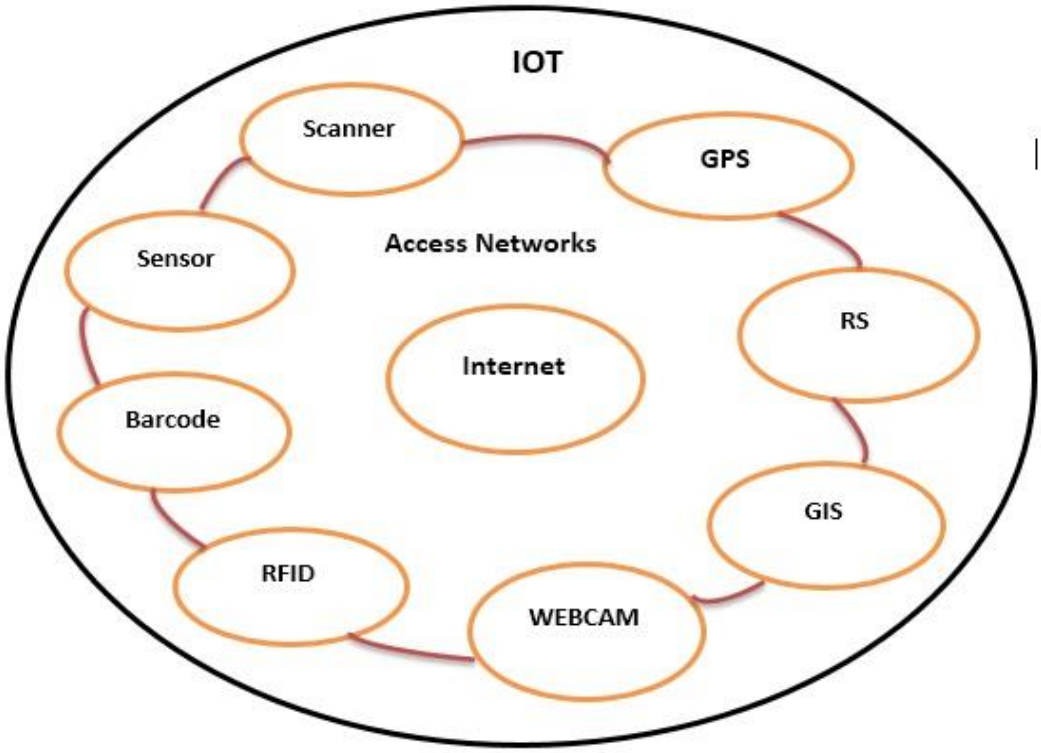

Figure 2.2: Concept Model of IoT. [18]

Progress in programming and nano-technology mean that small things can communicate and connect. The combination of these techniques creates an IoT that combines objects in sensual and smart ways to gain a common understanding, reliable data transfer and smart intelligence [19].

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